INSTRUCTION MANUAL

MODEL 56

PHASE JITTER METER

HLI

HEKIMIAN LABORATORIES, INC.

15825 SHADY GROVE ROAD

ROCKVILLE, MARYLAND 20850

INSTRUCTION MANUAL

MODEL 56

PHASE JITTER METER

MANUFACTURED BY

HEKIMIAN LABORATORIES, INC.
15825 Shady Grove Road
Rockville, Maryland 20850

Part No. 56-014

Printed: February 1974

CONTENTS

SECTION			PAGE
1.0	INTRODUCTION		1-1
	1.1	GENERAL DESCRIPTION	1-1
	1.2	SPECIFICATIONS	1-2
2.0	INSTALLATION		2-1
	2.1	GENERAL	2-1
	2.2	INSTALLATION	2-1
3.0	OPERATION		3-1
	3.1	GENERAL	3-1
	3.2	CONTROLS AND INDICATORS	3-1
	3.3	OPERATING ADJUSTMENTS	3-2
		3.3.1 General	3-2
		3.3.2 Jitter Measurement	3-3
		3.3.3 CAUTION Lamp	3-3
		3.3.4 Frequency Offset Measurement	3-3
		3.3.5 External Jitter Output	3-4
	3.4	MEASUREMENT METHODS	3-4
		3.4.1 General	3-4
		3.4.2 End-to-End Measurement	3-7
		3.4.3 Loop Measurements	3-7
		3.4.4 Direct High Frequency Carrier Measurement	3-8
		3.4.5 Direct Group and High Frequency Carrier Measurement	3-8
		3.4.6 High Frequency Carrier Measurement	3-9
4.0	THEORY OF OPERATION		4-1
	4.1	GENERAL	4-1
		4.1.1 Input	4-1
		4.1.2 Phase Jitter Measurement	4-3

SECTION			PAGE
4.2	DETAILED CIRCUIT OPERATION		4-3
	4.2.1	Line Input	4-3
	4.2.2	Signal Limiter	4-4
	4.2.3	Digital Phase Detector	4-4
	4.2.4	300 Hz Low Pass Filter	4-5
	4.2.5	Phase Locked Reference Oscillator	4-5
	4.2.6	20 Hz High Pass Filter	4-6
	4.2.7	Peak-to-Peak Detector	4-6
	4.2.8	Out-of-Lock Detector	4-6
	4.2.9	Level Detector	4-7
	4.2.10	CAUTION Lamp	4-8
	4.2.11	Meter Circuit	4-8
	4.2.12	Power Supply	4-9
5.0	MAINTENANCE AND CALIBRATION		5-1
5.1	MAINTENANCE PHILOSOPHY		5-1
5.2	PREVENTIVE MAINTENANCE		5-1
	5.2.1	General	5-1
	5.2.2	Input Level Check	5-2
	5.2.3	Input Frequency Check	5-2
	5.2.4	Jitter Measurement Check	5-2
	5.2.5	Caution Indicator Check	5-2
5.3	CORRECTIVE MAINTENANCE		5-3
	5.3.1	Trouble Shooting	5-3
	5.3.2	Symptom Analysis	5-3
	5.3.3	Circuit Level Trouble Shooting	5-5
		5.3.3.1 Input Circuitry	5-5
		5.3.3.2 Phase Detector and Phase-Locked Oscillator	5-6
		5.3.3.3 Peak-to-Peak Jitter Detector	5-8
		5.3.3.4 Out-of-Lock Detector	5-9
		5.3.3.5 Level Detector	5-9
		5.3.3.6 Power Supply	5-10
	5.3.4	Calibration	5-11
		5.3.4.1 Input Level Meter	5-11
		5.3.4.2 Phase-Locked Oscillator Frequency and Frequency Meter Scale	5-11

SECTION PAGE

5.3.4.3 Peak-to-Peak Jitter 5-12

5.3.4.3.1 30° Peak-to-Peak Jitter Range 5-14

5.3.4.3.2 3° Peak-to-Peak Jitter Range 5-14

5.3.4.4 Level Detector 5-15

5.3.4.5 Out-of-Lock Detector 5-15

5.3.4.6 Power Supply Voltage 5-15

5.4 PARTS IDENTIFICATION 5-16

ILLUSTRATIONS

FIGURE		PAGE
1-1	MODEL 56 PHASE JITTER METER	1-4
3-1	ERROR IN P-P JITTER READINGS RESULTING FROM VOICE FREQUENCY CHANNEL NOISE	3-6
3-2	END TO END MEASUREMENT	3-8
3-3	LOOP MEASUREMENT	3-8
3-4	HIGH FREQUENCY CARRIER MEASUREMENT	3-8
4-1	MODEL 56 BLOCK DIAGRAM	4-2
5-1	MODEL 56 WAVEFORMS	5-7
5-2	PHASE JITTER CALIBRATION TEST JIGS	5-13
5-3	MODEL 56 MAINFRAME SCHEMATIC DIAGRAM	5-27
5-4	HLI 56-200 P.C. BOARD COMPONENT LAYOUT	5-28
5-5	HLI 56-200 P.C. BOARD SCHEMATIC DIAGRAM	5-29
5-6	POWER SUPPLY COMPONENT LAYOUT	5-30
5-7	POWER SUPPLY SCHEMATIC DIAGRAM	5-31

TABLES

TABLE		
1-1	SPECIFICATIONS	1-3
3-1	CONTROLS AND INDICATORS	3-1
5-1	MAINTENANCE TEST EQUIPMENT	5-3
5-2	SYMPTOM ANALYSIS	5-4
5-3	MODEL 56 MAINFRAME PARTS LIST	5-17
5-4	HLI 56-200 P.C. BOARD PARTS LIST	5-18
5-5	POWER SUPPLY PARTS LIST	5-25

SECTION 1.0

INTRODUCTION

1.1 GENERAL DESCRIPTION

The Model 56 Phase Jitter Meter is designed to measure the phase modulation, or "jitter," introduced on signals transmitted through a voice frequency communications channel. High-speed data transmissions of 1200 bits per second and above are particularly sensitive to this parameter which ranks in importance with signal-to-noise ratio, impulse noise, frequency response, and envelope delay distortion in determining channel error performance. Phase jitter may be introduced by the transmission medium, terminating, multiplex and radio equipments. The ability to measure this important performance parameter and isolate those transmission links or equipments which are causing unacceptable performance is essential to the maintenance of a high grade of service.

The Model 56 Phase Jitter Meter measures peak-to-peak phase jitter on 3° and 30° full-scale ranges and measures input signal levels on 0 dBm and -20 dBm meter ranges and input frequency from 990 to 1030 Hz. The unit operates with both conventional and "T" carrier test frequencies and a caution lamp indicates when the input frequency or level is incorrect. Selectable 600 and 900 ohm termination impedances with line-hold and a bridging position are provided. A carrier output provides a noise-free duplicate of the input test signal and may be used for accurate measurements of frequency offsets with an electronic

frequency counter, even on noisy channels. The unit is completely self-contained and may be used to make end-to-end and loop measurements using any good quality audio oscillator as a test signal source. The Model 56 is contained in a hinged cover transit case measuring 6" high by 9" wide by 7 1/2" deep. A compartmented cover is provided for cable and test cord storage.

1.2 SPECIFICATIONS

The mechanical and electrical specifications for the Model 56 Phase Jitter Meter are contained in Table 1-1. A photograph of the Model 56 is shown in Figure 1-1.

TABLE 1-1

SPECIFICATIONS

INPUT	
Frequency	990 - 1030 Hz
Level	-40 to +10 dBm
Impedance	600Ω, 900Ω, Bridge (24,000Ω)
Line Hold	600Ω, and 900Ω positions
Line Hold D.C. Resistance	250Ω (maximum)
Longitudinal Balance	Greater than 60 dB
METER	
P-P Phase Jitter	3° and 30° full scale (±5% plus ±0.2°)
Input Level	0 and -20 dBm ranges (±1.0 dB)
Input Frequency	990 to 1030 Hz (±2 Hz)
EXTERNAL CARRIER OUTPUT	
Impedance	10,000Ω
Level	8 v p-p
EXTERNAL JITTER OUTPUT	
Impedance	22K Ω
Level	100MV/degree (Approx.)
TEMPERATURE RANGE	
Operating	0° to +50°C
Storage	-10° to +75°C
VOLTAGE	105 to 125 vac 50 - 60 Hz
POWER	15 watts
DIMENSIONS	6" H, 9" W, 7.5" D
WEIGHT	8 lbs.

FIGURE 1-1 THE MODEL 56 PHASE JITTER METER

SECTION 2.0

INSTALLATION

2.1 GENERAL

The Model 56 Phase Jitter Meter was designed for ease of operation and installation. After the unit has been removed from its shipping container, perform a complete external visual inspection for possible damage. To inspect the interior, open the cover and detach it from the case. Turn the unit face down, remove the four screws located on the bottom of the unit, and lift the case off the inner assembly. Any damage due to shipping should be immediately reported to the shipping agency.

All internal adjustments have been set at the factory and no further adjustment is required prior to installation or use of the equipment.

2.2 INSTALLATION

Primary power is supplied through the line cord packed in the compartmented cover of the transit case. The cover may be opened by pressing the gray tabs of the two fasteners holding the compartment lid. The cord is connected to the AC receptacle located on the front panel of the instrument.

Signal input lines are connected to the front panel binding posts or the Western Electric 310 jack. Shielded cable is recommended for all input connections.

Connection to the CARRIER and JITTER outputs are made using a standard Western Electric 310 plug. The signal is on the tip connec-

tion and the ring and sleeve are grounded.

For fixed station applications, an optional rack mounting shelf is available. This shelf mounts in a standard 19" relay rack and occupies 8 3/4" of verticle rack space. The behind-the-panel depth is 9" including storage provisions for transit case cover.

SECTION 3.0

OPERATION

3.1 GENERAL

This section contains a description of the controls and indicators, operating procedures and measurement methods to be used with the Model 56. Prior to operation, be sure that all connections to the instrument are made in accordance with the instructions of Section 2.0, Installation.

3.2 CONTROLS AND INDICATORS

The controls and indicators used in operating the Model 56 are described in Table 3-1. All controls are located on the front panel. No internal adjustments are required during normal operation. Adjustment procedures for internal controls are contained in Section 5.0, Maintenance.

TABLE 3-1

CONTROLS AND INDICATORS

DESIGNATION	REFERENCE	FUNCTION
POWER Switch and Indicator Lamp	S101 DS101	Applies AC primary power to the instrument.
INPUT Terminals	J101, J102, J103, J104	Provides input connections for wire leads, clip leads, banana plugs and Western Electric 310 plugs.
INPUT Switch	S102	Selects input line terminations of 600 ohm, 900 ohm, or bridging (25,000 ohm). Line hold provided in 600 and 900 ohm positions.

DESIGNATION	REFERENCE	FUNCTION
METER Switch	S103	Selects the input to the front panel meter which displays input level, peak-to-peak jitter, and input frequency.
METER	M101	Displays the parameter selected by the meter switch.
CAUTION Indicator	DS102	Glows when either the input level or frequency is incorrect.
CARRIER Jack	J106	Provides the phase-locked oscillator signal between tip and ring/sleeve (gnd).
JITTER Jack	J107	Provides the detected jitter output for recording or monitoring.

3.3 OPERATING ADJUSTMENTS

This section presents the operational adjustments for the Model 56. These adjustments are summarized in the OPERATING INSTRUCTIONS on the storage compartment lid located in the cover of the portable case.

3.3.1 General

All measurements are made in an idle voice frequency channel using a test signal. The test signal frequency should be between 990 Hz and 1030 Hz. This range accommodates both the conventional 1000 Hz and 1020 Hz "T" carrier test signal. Measurements are generally made at a test level of -13 dBm0. The test set will accept input levels from -40 to +10 dBm.

Measurements may be made using a test signal from any good quality audio oscillator. Commerical oscillators typically have less than 1.0° peak-to-peak jitter in their output. Operational checkout procedures are described in Section 5.2.

3.3.2 Jitter Measurement

Connect the channel under test to the 990-1030 Hz INPUT terminals of the Model 56, using either the five-way binding posts or the Western Electric 310 jack. Select the desired terminating impedance, and verify the proper input signal level using the INPUT LEVEL meter position, and the proper input signal frequency using the FREQUENCY meter position. Any test signal frequency outside the range of 990 to 1030 Hz will appear as an off-scale or center scale reading with an illuminated CAUTION lamp. Select the lowest peak-to-peak jitter range which gives a consistent on-scale reading. When short term fluctuations of the phase jitter are present, the meter reading should be averaged to determine a final measurement figure.

3.3.3. CAUTION Lamp

The CAUTION lamp will illuminate whenever the test signal frequency is not between 990 and 1030 Hz or the input level is below -40 dBm. The CAUTION lamp must be extinguished before valid measurements can be made.

3.3.4 Frequency Offset Measurement

Frequency offset measurements may be made with an electronic frequency counter connected to the tip (signal) and ring/sleeve (gnd) connections of the CARRIER jack. The carrier output is from the phase-

locked oscillator which is locked in frequency and phase with the input signal. The phase-locked loop provides an effective narrow band filter of approximately 20 Hz around the test signal, resulting in an almost noise-free CARRIER output. Extremely accurate and stable measurements may be made in a noisy channel which would not be suitable for direct frequency offset measurements with an electronic frequency counter.

The CARRIER output may also be used to synchronize an oscilloscope used to observe the wideband channel test signal.

3.3.5 External Jitter Output

The demodulated jitter signal is also available on the tip (signal) and ring/sleeve (gnd) of the JITTER jack. This signal may be used for spectrum analysis of the jitter modulation to determine individual jitter frequencies and their magnitude, and it may also be directly recorded on a high speed strip chart recorder.

3.4 MEASUREMENT METHODS

This section presents a general discussion of phase jitter, and the various ways in which the Model 56 may be used to measure this important parameter.

3.4.1 General

Phase modulation, or "phase jitter," introduced by voice frequency transmission facilities has an insignificant effect on voice intelligibility but can introduce errors in data transmission. Just as signal amplitude is affected by channel-induced amplitude

noise, i.e., thermal, crosstalk, etc., the phase of the signal is affected by channel-induced phase jitter. Phase jitter generally occurs during a frequency translation process where power supply hum and power line and ringing frequency ground currents phase modulate the translation oscillators. Direct frequency modulation may also take place under certain conditions.

Phase and amplitude variations may also be generated by other channel characteristics, principally additive wideband noise, spurious signals, (crosstalk, etc.) and amplitude impulse noise. These characteristics are independently specified and measured in evaluating channel performance and their effect on the jitter measurement has been minimized in the design of the Model 56. Wideband noise, however, may still be a source of error in the phase jitter measurement and could cause readings higher than the actual jitter level. Figure 3-1 shows the error which will result as a function of test-signal-to-noise-level ratios for true phase jitter levels of 11.4° and 1°. The test-signal-to-noise ratio may be improved by increasing the test tone levels to the point of channel nonlinearity, although this is generally not recommended.

Phase variations in "T" carrier is the result of quantizing noise effects rather than direct phase or frequency modulation of the voice frequency signal. Valid phase jitter measurements may be made directly over "T" carrier or tandem circuits utilizing "T" carrier, as these will indicate the degree of phase jitter seem by equipment

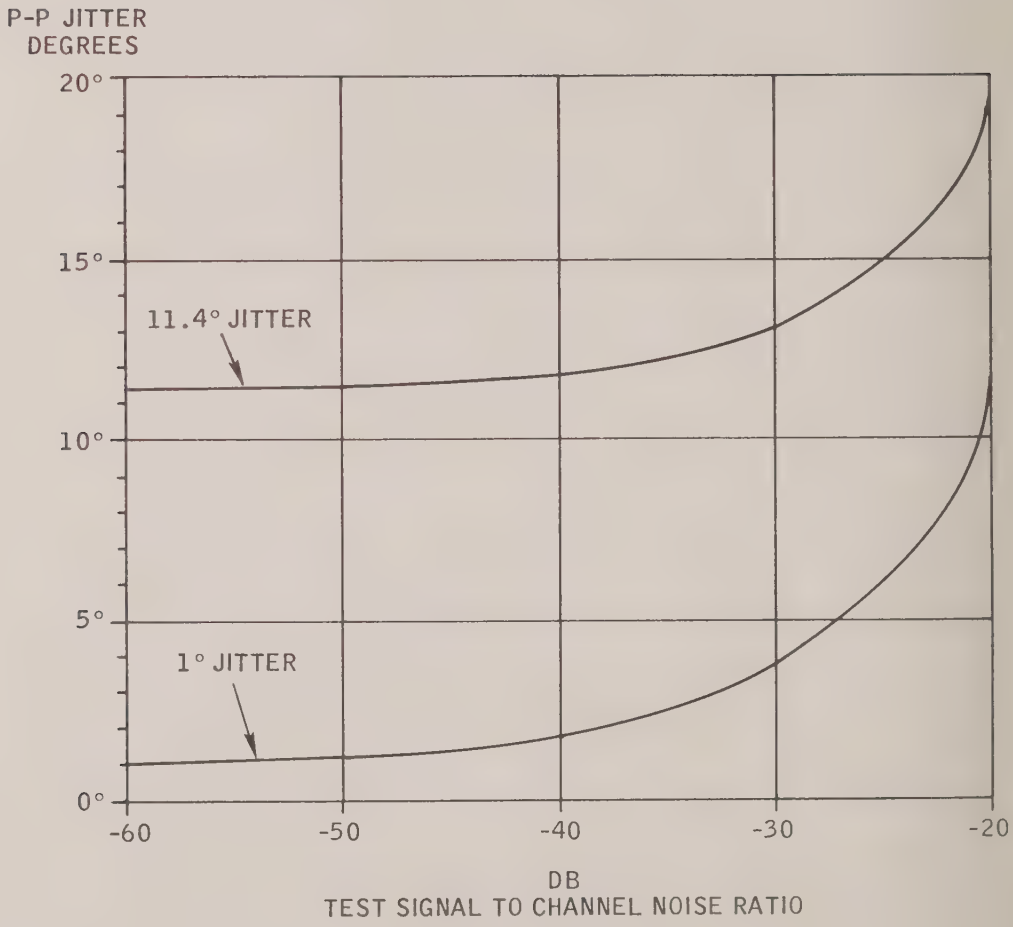


FIGURE 3-1 ERROR IN P-P JITTER READINGS RESULTING FROM VOICE FREQUENCY CHANNEL NOISE

connected to the circuit. However, they are not necessarily indicative of the "T" carrier channel quality.

3.4.2 End-to-End Measurement

End-to-end measurements are made as shown in Figure 3-2. The 1020 Hz test signal may be obtained from an HLI Model 44A, Model 48 or a commercial oscillator. Either balanced or unbalanced circuits may be connected to the instrument. The transmission test level is typically -13 dBm0. The instrument is adjusted, and measurements are made in accordance with the operating adjustments of Section 3.3.

To locate sources of excessive phase jitter on a long distance point-to-point circuit, test signal transmissions from various voice frequency drop points may be used to isolate the segment of the circuit causing excessive jitter. The same technique may also be used in isolating local sources of jitter, by transmitting test signals from various test points within a facility or equipment.

3.4.3 Loop Measurements

When a far-end test signal source is not available, or it is inconvenient to make end-to-end tests, loop measurements may be performed as shown in Figure 3-3. At the distant end, the receive and transmit levels must be matched, i.e., if the specified transmit and receive levels are not equal, it is essential that an amplifier or attenuator network be used to match them. This must be done to preserve the signal-to-noise ratio of the test signal and to eliminate

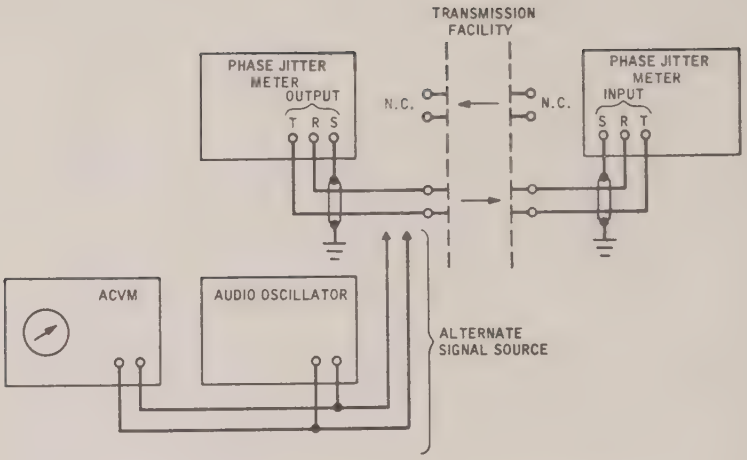


FIGURE 3–2 END TO END MEASUREMENT

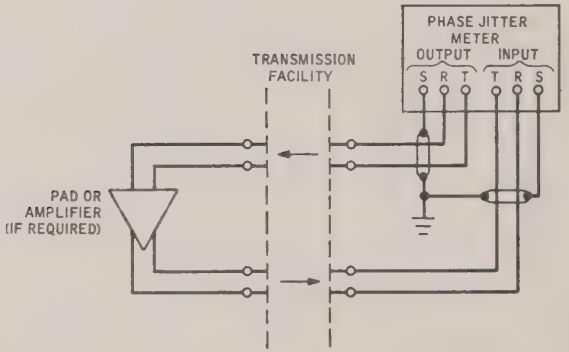


FIGURE 3–3 LOOP MEASUREMENT

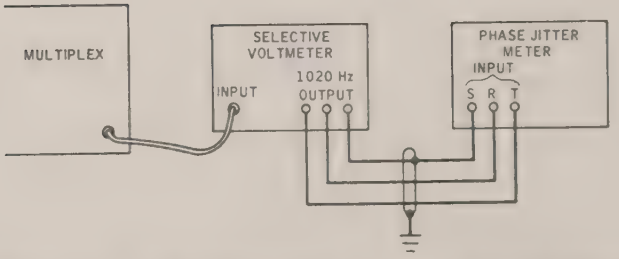


FIGURE 3–4 HIGH FREQUENCY CARRIER MEASUREMENT

overloading of the transmission facility.

Loop measurements are not as desirable as end-to-end measurements. In general, one cannot assume that the total phase jitter measured on a loop basis is equally divided between the transmit and receive circuits. In some cases, the phase jitter in each direction may tend to cancel, and unlike channel noise, will result in a lower overall loop measurement than the sum of individual end-to-end measurements.

3.4.4 Direct High Frequency Carrier Measurement

For direct carrier measurements between 300 kHz and 10.0 MHz, a "Carrier Pilot" option is offered for the Model 56 which allows direct measurement of any two carrier pilot or supply frequencies. Such measurements are desirable when performing maintenance on various multiplex and carrier equipments and this capability extends the usefulness of the instrument. Typical measurement frequencies are 3.100 MHz and 3.396 MHz. With this option, an additional input selector switch and W.E. 75 ohm coax connector are provided on the front panel, and the carrier pilot level is directly displayed on the INPUT LEVEL position of the meter. The unit maintains its full voice frequency capability.

3.4.5 Direct Group and High Frequency Carrier Measurement

Phase jitter measurements may be made directly in a wideband data channel or a multiplex group, master group or super group using the "Wideband/Group Measurement" option. This option provides

up to 5 selected measurement frequencies in the range of 4.0 kHz to 10.0 MHz and uses a double conversion technique to minimize noise image problems when making jitter measurements in the group channel. The test signal is connected directly to the W.E. 75 ohm coax connector located on the front panel and the operating frequency is selected by the INPUT selector switch.

3.4.6 High Frequency Carrier Measurement

The Phase Jitter Meter may be used with additional equipment to measure phase jitter on carriers in a group or super group base-band. To measure high frequency carriers, it is necessary to use a frequency translation device to hetrodyne the desired carrier to the 990 to 1030 Hz range. This is done using a tunable selective voltmeter having a translated voice frequency output.

A typical equipment connection is shown in Figure 3-4. The selective voltmeter is tuned to the desired carrier, oscillator, or pilot tone frequency, and the translated output is connected to the INPUT of the Model 56. The bandwidth of the translation device should be greater than 800 Hz but not more than 4 kHz.

When looking for low levels (less than 3°) of phase jitter using this technique, the signal-to-noise ratio at the output of the selective voltmeter must be taken into account in determining the true value of phase jitter (See Figure 3-1). It is also possible that the translation device itself may introduce jitter in the translated signal; this may be verified by measuring a carrier source having a known level of phase jitter.

SECTION 4.0

THEORY OF OPERATION

4.1 GENERAL

This section provides a general theory of operation followed by detailed circuit operation on a functional block basis. The Model 56 is entirely solid state and makes extensive use of integrated circuit differential operational amplifiers and conventional discrete components. Two types of differential operational amplifiers are used in the unit. Where wide bandwidth and fast rise times are required, the externally compensated Type MC1437 is used, and where a 10 kHz bandwidth is adequate, the internally compensated Type MC1458 is used. Discussions of operational amplifier configurations and operation are available in a number of current reference texts. Conventional transistors are used in the remainder of the circuitry. A simplified block diagram of the Model 56 is shown in Figure 4-1.

4.1.1 Input

The balanced or unbalanced input signal is terminated by the input switch in 600 ohm, 900 ohm, or bridging impedances. Line holding is provided in the 600 and 900 ohm positions by a holding coil. A simple high pass filter precedes the input transformer, and rejects 60 cycle signals which appear at the input. The transformer is connected to a 5 pole low pass filter which attenuates spurious signals and noise above 2.0 kHz. This filter is followed by the signal limiter and a 20 dB amplifier which supplies the -20 dB range of the input level meter

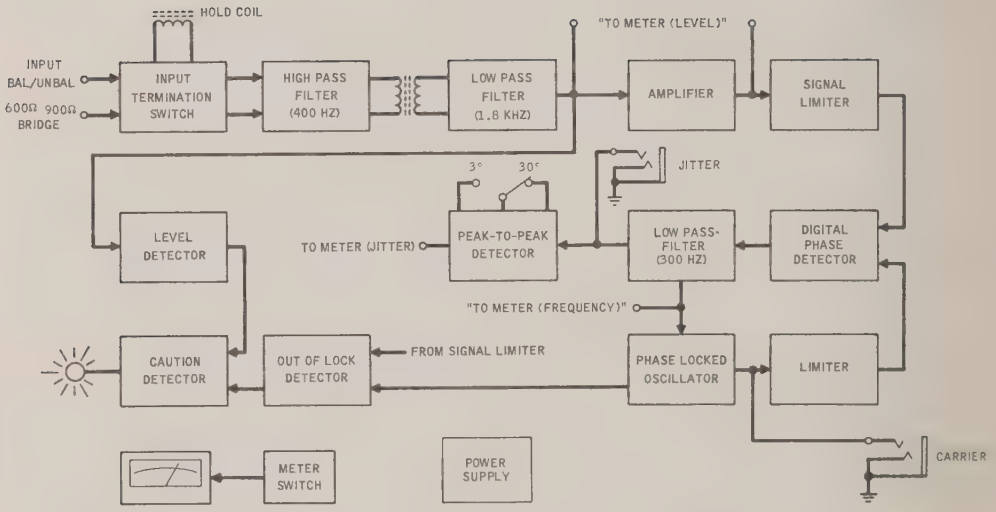


FIGURE 4-1 MODEL 56 BLOCK DIAGRAM

and the level detector.

4.1.2 Phase Jitter Measurement

The filtered input signal is routed to the signal limiter which provides a square wave replica of the input signal zero crossings, and becomes one input to the digital phase detector. This detector compares the input signal with the long time constant phase locked reference oscillator and generates DC pulses whose width are proportional to the phase difference. These pulses are then changed to a DC voltage proportional to that phase difference by the 300 Hz low pass filter. This filter's output is used to control the phase locked reference oscillator, and supplies the phase jitter signal to the peak-to-peak jitter detector.

The signal limiter also supplies an input to the out of lock detector which is combined with the output of the level detector to generate the CAUTION light indication.

4.2 DETAILED CIRCUIT OPERATION

4.2.1 Line Input

The input signal is connected using the five-way binding post or a Western Electric Type 310 jack. Both balanced and unbalanced signals may be accommodated. The input is terminated by the INPUT switch S102, and DC holding coil L101 is connected across the input in the 600 and 900 ohm termination positions. In the BRIDGING position (approximately 24K input impedance), the holding coil is removed to allow dial-through operation. The signal is then applied to

a two capacitor d.c. blocking input filter C201, 202, designed to reject 60 cycle pick-up on the line. The filter's output is connected to the input transformer T201 which performs the balanced to unbalanced transformation. The transformer secondary feeds a low pass filter IC201A, IC201B, which provides a 5-pole Butterworth response using active filter techniques, eliminating the requirement for conventional inductors. Input voltage transient protection is supplied by diodes D201, 202. The output of IC201B provides the filtered input signal utilized by the 20 dB meter amplifier IC202A, and the signal limiter.

4.2.2 Signal Limiter

The input signal limiter IC203A is a differential operational amplifier used as an open-loop gain zero crossing detector with DC stabilization provided by R214, 215, C210. Amplifier phase compensation is provided by C211, 212. This amplifier provides a square wave replica of the input signal zero crossings.

4.2.3 Digital Phase Detector

The output from IC203A and the phase locked reference oscillator output from IC204A are connected to the two inputs of the digital phase detector. Transistors Q203, 204 and their associated components form an "exclusive or" gate which provides a bipolar output pulse whose width is proportional to the phase difference (zero crossings times) of the two inputs. The back-to-back zener diodes D206, 207 provide a constant amplitude pulse to the circuitry that follows.

4.2.4 300 Hz Low Pass Filter

The carrier frequency present at the output of the digital phase detector is removed, and the upper limit of the phase jitter spectrum determined by the low pass filter consisting of IC205A, B, and their related components. This filter provides a 5-pole 300 Hz Butterworth response using active filter design techniques. To achieve the desired bandwidth accuracy, 1% resistors and 5% capacitors are used in this filter. The output of the filter IC205B, Pin 7, furnishes the signal to the FREQUENCY position of the panel meter through R249, 250 and the bias offset network R251, 252. The phase locked loop control voltage is also obtained from the output of the filter at IC205B.

4.2.5 Phase Locked Reference Oscillator

The output of the low pass filter is a DC voltage proportional to the instantaneous phase difference between the input and reference oscillator signals. This voltage is further filtered by the network R201, 263, and C227. This network provides an over-damped phase locked loop response characteristic and its output controls a conductance modulator consisting of Q208, 209, 210, and D213, 214. This circuit effectively varies the reactance across the "bridge tee" oscillator feed back circuit, and determines the output frequency and phase of the oscillator. The oscillator frequency is adjusted by trimmer R274. Its output is connected to the reference limiter IC204A which provides a square wave replica of the phase locked oscillator

signal to the digital phase detector.

4.2.6 20 Hz High Pass Filter

The output of the 300 Hz low pass filter is high pass filtered by IC206B, which is a 2-pole 20 Hz active filter, using C222, 223, 224, and R253, 254. This filter also provides isolation and signal amplification for the circuits that follow it and is connected to the JITTER jack thru R248.

4.2.7 Peak-to-Peak Detector

The high pass amplifier feeds the high linearity peak-to-peak detector consisting of amplifier IC206A, the positive peak detector Q212, and the negative peak detector Q211. The gain of the detector is controlled by the meter switch providing near unity amplifier gain in the 30° position, and 10 times that gain in the 3° position. R257 provides the calibration of the 30° range and R258 adjusts the calibration of the 3° range. The positive peak is stored on capacitor C225, and the negative peak on capacitor C226. Their outputs are applied to the meter through multiplier resistor R262. Their outputs are applied to the meter through multiplier resistor R262. This detector is calibrated in terms of the peak-to-peak value of a sine wave and responds to approximately the 98% level of white noise.

4.2.8 Out of Lock Detector

The out of lock detector is used to detect an "out of range" lock or lack of phase lock in the reference oscillator. This is then

combined with the dropout detector to illuminate the CAUTION lamp if either the phase lock or input level are incorrect.

The out-of-lock detector uses a digital phase detector Q205, 206, similar to that of the jitter phase detector. It is driven by the input signal limiter IC203A and the out of lock limiter IC204B which utilizes a 90° phase shifted input signal obtained through the network R276, C237. This results in a maximum positive voltage output from the digital phase detector that corresponds to the center scale meter reading in the FREQUENCY meter position. As the input frequency is varied in either direction, the voltage becomes less positive, and the out of lock threshold detector IC203B is set to provide a change of output when the acceptable phase lock range has been exceeded. When phase lock has not been obtained, the output voltage has an average value of 0 volts which generates an out of lock indication from the threshold detector. The output of the digital phase detector is summed through R230, 231, with the threshold set voltage from R232. Hysteresis is provided in the threshold detector by R233, 234. When an out of lock condition exists, a positive voltage appears at the output of IC203B.

4.2.9 Level Detector

The level detector monitors the input signal level and is activated whenever this level drops below -40 dBm for more than 100 milliseconds.

The input signal from IC202A is connected to a long-tail pair, Q201 and Q202, peak detector circuit having excellent detector linearity, dynamic range and DC level stability. The 100 millisecond detector time-constant is determined by C213 and R218. The detector output is connected to one input of the input level threshold detector, IC202B, where it is compared against the threshold voltage set by R239. This threshold voltage is set so that the output of the threshold detector changes state when the input signal level drops below -40 dBm.

4.2.10 CAUTION Lamp

The CAUTION lamp is driven by transistor Q207 and operates directly from the +28 volt supply. The driving signals from the input level detector and out-of-lock detector are combined in the diode "or" gate, D210 and D211. A positive output from the threshold detector outputs will activate the CAUTION indicator. Reverse voltage protection is provided by diode D212.

4.2.11 Meter Circuit

Input level, peak-to-peak phase jitter and frequency are monitored using the front panel-mounted, 50-microamp meter, M101. The meter input is selected by the meter switch, S103. For level monitoring, a bridge rectifier consisting of D301, D302, and R301 through R303 is provided. Input level calibration is provided by R301, and all meter rectifier components are mounted on PC Board 56-300, located on the rear terminals of the meter housing.

4.2.12 Power Supply

A dual tracking +15 and -15 volt DC power supply is utilized in this instrument. It provides .01% line and .05% load regulation, and has a temperature coefficient of .02V per degree C. Noise and ripple on the power supply output are 4.0 millivolt rms maximum. Current capacity is 200 millamperes for each supply voltage. Unregulated 28 volt DC power for the indicator lamps is also provided by the power supply board.

The power supply is controlled by the front panel on-off push switch S101. A 1/2 amp slow-blow fuse F101 is provided for protection of the line circuitry.

The power supply receives the low voltage ac from transformer T101. This transformer has a dual primary and is suitable for 115/230 volt ac operation (optional). A center tapped secondary feeds the full wave rectifiers and filter capacitors for the dual 15 volt supply. The zener reference voltage from D505 is amplified by transistors Q505, 508, which regulate the series pass transistor Q501. Current limiting is provided by Q504 and is set for 200 milliamps. Output voltage is controlled by R416. Additional filtering is provided by C507 and reverse voltage protection is provided by diode D503.

A similar arrangement is used in the +15 volt regulated supply. This regulator obtains its reference boltage from the -15 volt supply to provide tracking outputs.

The second winding of the power transformer provides the low voltage ac input to the unregulated, unfiltered 28 volt supply. The transformer output is rectified by D502 and transient suppression is provided by C503. No additional filtering is required.

SECTION 5.0

MAINTENANCE AND CALIBRATION

5.1 MAINTENANCE PHILOSOPHY

Maintenance procedures for the Model 56 are divided into preventive and corrective classifications. Preventive maintenance consists of the routine performance checks which may be made using the front panel controls of the instrument. Corrective maintenance covers symptom analysis, troubleshooting, and recalibration of the instrument.

5.2 PREVENTIVE MAINTENANCE

5.2.1 General

The preventive maintenance procedures described in the following sections are used by the operator and maintenance personnel to verify proper instrument operation using the front panel controls. If proper operation is not achieved, see Section 5.3 for corrective maintenance procedures.

Periodic cleaning, lubrication, or inspection of the Model 56 is not required.

All of the following checks are made using an audio sine wave generator or other variable frequency and level signal source as an input signal.

5.2.2 Input Level Check

With a 0 dBm 1.0 kHz input signal, place the meter switch in the 0 dBm INPUT LEVEL position, and verify that the 0 dBm (±1.0 dB) reading is displayed on the meter. Reduce the input level to -20 dBm and place the meter switch in the -20 dBm (±1.0 dB) INPUT LEVEL position. Verify that the meter again reads correctly.

Absolute calibration of the internal level meter may be checked by comparison with an accurate external standard meter connected in parallel across the INPUT terminals.

5.2.3 Input Frequency Check

Using a frequency counter to set the test signal generator verify that the proper frequency indication (±2.0 Hz) is given with the meter switch in the FREQUENCY position.

5.2.4 Jitter Measurement Check

Verify that the 3° P-P and 30° P-P JITTER positions of the meter switch provide an up scale meter reading when small changes are made in the test signal generators frequency setting.

5.2.5 Caution Indicator Check

Place the meter switch in the FREQUENCY position, and slowly vary the test generator frequency. Verify that the CAUTION lamp illuminates when the meter reading has gone slightly off scale at each end of the meter scale. With the input frequency at 1.0 kHz, reduce the input level below -40 dBm and verify that the CAUTION lamp illuminates.

5.3 CORRECTIVE MAINTENANCE

5.3.1 Trouble Shooting

This section covers symptom analysis, circuit level trouble shooting and calibration procedures for the Model 56.

No specialized mechanical assembly or disassembly procedures are required. Accepted practices should be followed when repair is undertaken on main frame components or the printed circuit boards. Recommended trouble shooting techniques are based on signal tracing methods where a known input signal is used and the level and waveforms are verified as the signal progresses through the circuitry. Typical test equipment required to perform the trouble shooting procedures are listed in Table 5-1.

TABLE 5-1

MAINTENANCE TEST EQUIPMENT

DESCRIPTION	TYPICAL MODEL NUMBER
Audio oscillator	HP 204C
Calibration test jig	See Section 5.3.4.5
AC voltmeter	HP 400 EL
Oscilloscope, single channel, 1 MHz frequency response	Tektronix 323
Multitester	Simpson 260

5.3.2 Symptom Analysis

The preventive maintenance checks of Section 5.2 are used to isolate the area in which malfunction occurs. Table 5-2 summarizes possible fault locations for each of the preventive maintenance tests.

TABLE 5-2

SYMPTOM ANALYSIS

PREVENTIVE MAINTENANCE TEST	PROBABLE TROUBLE LOCATIONS
1. No response from any test	a. AC power cord b. Fuse c. Internal AC wiring or power switch, S101 d. Power supply
2. Input level check	
0 dBm position	a. IC201A or B b. Meter switch, S103; D301, or D302 c. Meter, M101
-20 dBm position	a. IC202A
3. Input frequency check	a. IC207 frequency incorrect b. Q203, Q204, Q208, Q209,Q210 IC203A, IC204A, IC205, IC207
4. Jitter measurement check	a. IC206 Q210, Q211 b. Meter switch, S103
5. CAUTION indicator check	a. Open lamp, DS102 b. Q207
No frequency indication	a. IC204B, IC203B, Q205, Q206
No level indication	a. Q201, Q202, IC202B

5.3.3 Circuit Level Trouble Shooting

The following sections describe the general procedures to be used in locating malfunctions. Where appropriate, performance standards, voltage levels, or waveform descriptions are provided to assist in the trouble shooting procedures. When a circuit has the proper input signal but the correct output cannot be measured, the components associated with that circuit should be checked and replaced if defective.

Before detailed troubleshooting is undertaken, the ±15 volt power supply should be checked. Low supply voltages may result from a malfunctioning power supply or excessive current being drawn by defective circuitry. A defective integrated circuit may sometimes be located by feeling the case temperature. Normally the integrated circuits are moderately warm to the touch. However, when defective, they can become extremely warm.

5.3.3.1 Input Circuitry

Input circuitry is checked using an 0 dBm, 1020 Hz input signal. With this input signal, verify that an 0 dBm meter reading is obtained in the 0 dBm INPUT LEVEL meter switch position. If 0 dBm cannot be obtained, check for input signals on both sides of the input transformer, T201.

Verify, with an oscilloscope, that the input signal with a level of approximately 0 dBm is present at the output of the first low-pass filter stage, IC201A, pin 1, and the output of the second low-pass filter stage at terminal 200-Q.

The input level meter may be checked using the same input signal, and should read within ±1.0 dB of an external reference voltmeter connected across the signal input. Calibration instructions are given in Section 5.3.4.1.

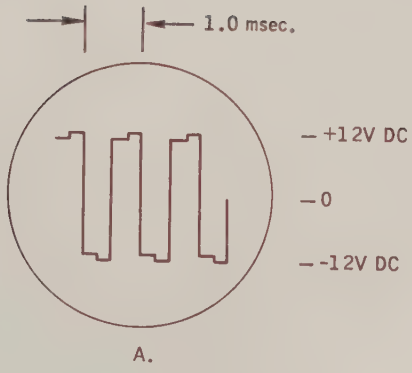
With an oscilloscope, verify that a ±12 volt, or greater, square wave at the test frequency is present at the output of the signal limiter, IC203A, pin 2. This waveform is shown in Figure 5-1A. If this waveform is not seen or either peak voltage is less than 10 volts, replace IC203A.

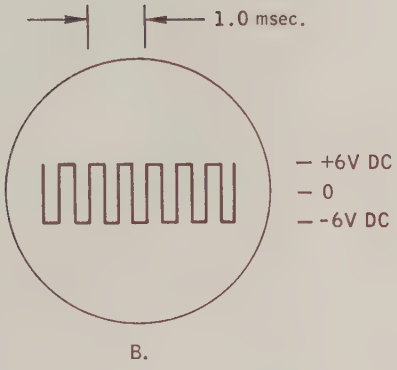
5.3.3.2 Phase Detector and Phase-Locked Oscillator

The phase-locked oscillator incorporates the phase detector consisting of Q203 and Q204; the low-pass filter, IC205A, B: a reactance modulator, Q208, Q209, Q210; oscillator, IC207; and the reference phase locked oscillator limiter, IC204A.

With no input signal, check with an oscilloscope for a 10 volt, or greater, peak-to-peak sine wave at pin 6 of IC204A. If no signal is seen, check the oscillator IC207, and its associated components. If a signal is present, verify that ±12 volt, or greater, square wave is present at the output of the reference oscillator limiter, pin 2 of IC204A. This waveform is shown in Figure 5-1A.

Connect a 1020 Hz test signal to the INPUT and verify that a ±6 volt pulse-chain is present at the junction of R223, R224, and D206. When the input frequency is 1010 Hz, the waveform shown in Figure 5-1B should be observed. Note that this waveform has a fre-





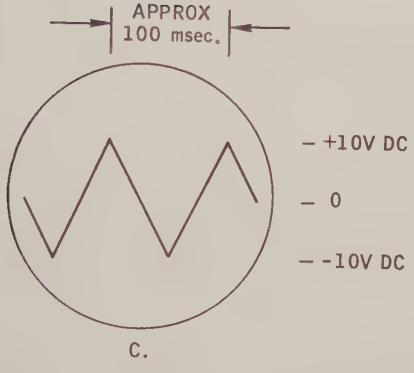


FIGURE 5-1 MODEL 56 WAVEFORMS

quency of twice the input frequency, i.e., 2020 Hz.

Place the instrument in an "out-of-lock" condition (Frequency substantially beyond 990-1030 Hz range, CAUTION light on) and monitor the output waveform of the first low-pass filter section, IC205A, pin 1. This waveform is shown in Figure 5-1C and will be a somewhat distorted isosceles wave varying at the difference frequency of the input signal and the phase-locked oscillator. Verify that a similar isosceles waveform is seen at the output of the second low-pass filter stage, IC205B, pin 7.

5.3.3.3 Peak-to-Peak Jitter Detector

The output of the low-pass filter is AC coupled to the 20 Hz high-pass filter/amplifier stage, IC206B, and then to the peak-to-peak detector consisting of IC206A, Q210, and Q211.

In the "out-of-lock" condition with the meter switch in the 30° P-P PHASE JITTER range, an isosceles waveform similar to Figure 5-1C should be seen at the high pass filter output, IC206B, pin 7. It may have its peak slightly clipped, and will have an amplitude of approximately ±12 volts.

In the 30° P-P PHASE JITTER meter position and in the out-of-lock condition, the dc voltage measured across C225 will be approximately +5 volts. The voltage measured across C226 will be approximately -5 volts dc.

5.3.3.4 Out-of-Lock Detector

The out-of-lock detector compares the limited input signal with the limited 90° phase-shifted reference oscillator signal in the digital phase detector, Q205 and Q206.

The phase-shifted reference oscillator signal output from IC204B, pin 12, should resemble that shown in Figure 5-1A. In the "out-of-lock" condition, the voltage at pin 9 of IC203B will be negative (use a high input impedance oscilloscope to observe). In the locked condition this voltage will become positive. As this dc voltage goes from minus to plus, the output of the threshold detector, IC203B, pin 12, should change from +12 volts to -12 volts. This voltage is coupled through D210 to the base of the caution indicator driver, Q207, causing the CAUTION lamp to light with a positive output voltage from IC203B.

5.3.3.5 Level Detector

The level detector consists of the peak amplitude detector circuit, Q201 and Q202, followed by a threshold detector, IC202B. This output is combined with the output of the out-of-lock threshold detector to operate the caution indicator.

A 0 dBm signal will result in a dc voltage of +2.6 volts at the emitter of Q202. This voltage will drop to near 0 volts when the input signal is removed. When this voltage drops below the reference voltage set by the level detector calibrate control, R237, the threshold detector output, IC202B, pin 7, will change from -12 to +12 volts. This change is used to drive the caution indicator driver, Q207, through diode D211.

5.3.3.6 Power Supply

The power supply consists of a dual tracking ±15 regulated supply and an unregulated 28 volt supply.

The AC input for the regulated supply should be 32 volts AC as measured across terminals A and B with a multitester. The rectified DC voltages across the filter capacitors C501, 502, should be ±32 volts respectively. If a proper negative output is measured, check the positive voltage regulator Q502, Q503, Q506, and Q507. If neither supply voltage is proper, initially check the negative regulator Q501, Q504, Q505, and Q508, which supplies the reference voltage to both regulators. If a defective regulator transistor is suspected and the heat sinks or either Q501 or Q502 are cool to the touch, replace that regulator transistor.

To verify that low voltage operation of the power supply is not the result of current limiting due to excessive load, temporarily disconnect the power supply leads from terminals G and I. Remeasure the supply voltages. If these are normal, connect both supply leads through an ammeter to measure current output. This should not exceed 160 milliamps. Currents greater than that are the result of problems external to the power supply.

If Q501 and Q502 are found to be satisfactory, first replace Q504, Q505, and Q508; then, if proper operation is not achieved, replace Q503, Q506, and Q507.

Following transistor replacement, reset power supply voltages in accordance with Section 5.3.4.6.

The low voltage AC input to the unregulated 28 volt supply should be 34 volts AC as measured with a multitester between terminals F and E. DC output is 28 ±4 volt DC and is measured between terminal D and ground. If the proper DC voltage is not obtained, check for shorts in external wiring and then replace D502.

5.3.4 Calibration

The following procedures are used to recalibrate, the input/level meter, the phase locked oscillator and frequency meter scale, the peak-to-peak jitter ranges, and the out-of-lock detector. Recalibration is normally required when maintenance has been performed on associated circuitry or when there is a reason to suspect the calibration is no longer accurate.

5.3.4.1 Input Level Meter

Step 1. Connect an external 1 kHz signal generator to the INPUT terminals at a level of 0 dBm.

Step 2. Connect a standard reference meter in parallel with the INPUT terminals. Be sure all ground connections are properly made.

Step 3. Adjust R301 (located on back of the meter terminals) to give a meter reading within ±0.1 dB of the meter reference.

5.3.4.2 Phase Locked Oscillator Frequency and Frequency Meter Scale

Step 1. Connect a 0 dBm test signal at a frequency of 1010 ±1 Hz to the INPUT terminals.

Step 2. Monitor the junction of R223, R224, and D206, and adjust the phase locked oscillator frequency control R274 to give a perfectly symmetrical square wave, i.e., 50% duty cycle, at this point.

Step 3. Change the test signal to a frequency of 990 ±1 Hz.

Step 4. Adjust the FREQ ZERO control R252 for a meter reading of 990 Hz in the FREQUENCY position of the meter switch.

Step 5. Reset the input frequency to 1030 ±1 Hz and adjust the FREQ RANGE control R250 for a meter reading of 1030 Hz.

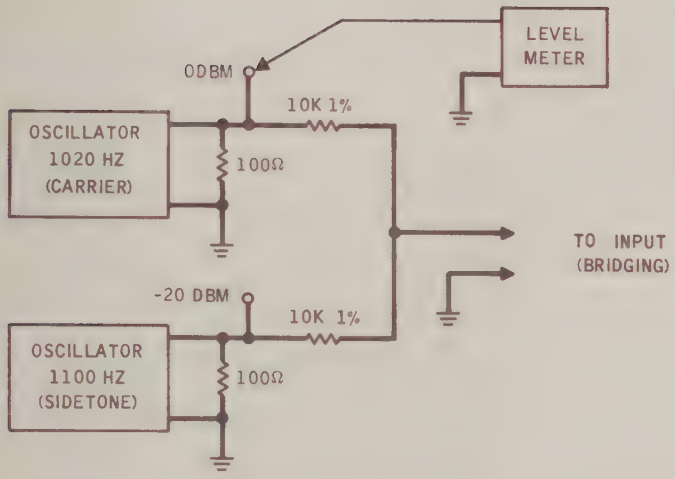
Step 6. Repeat steps 3 through 5 until the proper meter readings are obtained without further adjustment.

5.3.4.3 Peak-to-Peak Jitter

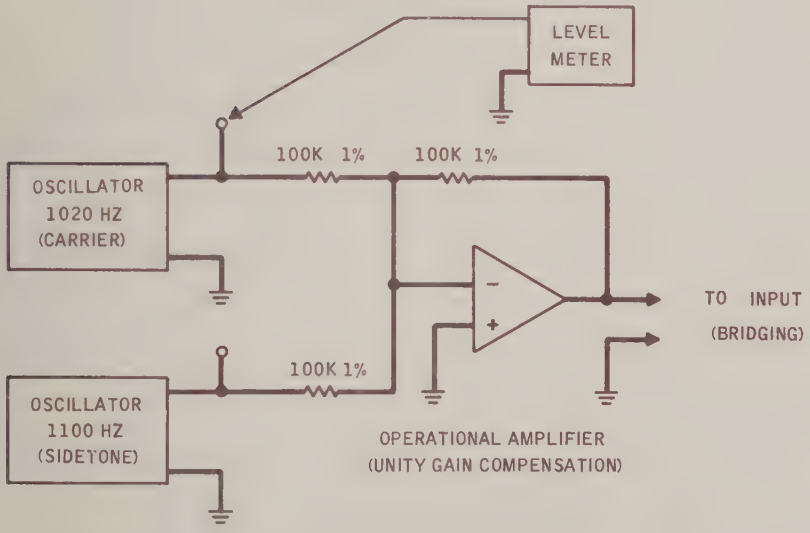
Step 1. The peak-to-peak jitter ranges are calibrated using a two-tone audio technique where the phase jitter reading is proportional to the level difference between two input signals.

Step 2. To perform this calibration, two audio oscillators having 1% or less harmonic distortion are connected using the special test fixtures shown in Figure 5-2. A wide variety of integrated circuits of discrete operational amplifiers may be used in the test fixture, including the MC1437L and MC1458G's used in the Model 56. Precision resistors of 1% tolerance are required in these networks. When external amplifier compensation is required, it should be provided for unity gain operation.

Step 3. Connect the oscillators as shown to the test fixture, and then connect the test fixture to the input of the Model 56. Set



A. RESISTOR TEST JIG (11.5 P-P JITTER ONLY)



B. OPERATIONAL AMPLIFIER TEST JIG

FIGURE 5-2 PHASE JITTER CALIBRATION TEST JIGS

the carrier oscillator for a frequency of 1020 Hz (±1 cycle) and set its output level to 0 dBm (±0.1 dB).

Step 4. Adjust the frequency of the sidetone oscillator to 1100 Hz. The output level of this oscillator will be varied to obtain the desired phase jitter calibration levels.

NOTE

Caution must be used in calibrating low values of phase jitter to ensure that no noise pickup, hum, etc., is introduced by the test fixture.

The carrier oscillator must have a low level of phase jitter in its output. This can be verified by the residual meter reading with the sidetone oscillator disconnected. If this reading is not below 0.15° peak-to-peak, on the 3° range, the carrier oscillator should be replaced with an audio oscillator providing this residual reading.

5.3.4.3.1 3° Peak-to-Peak Jitter Range (Always Perform First)

Step 1. Adjust the sidetone oscillator for an output level of -41.2 ±0.1 dBm. This setting corresponds to a peak-to-peak jitter level of 1.0°.

Step 2. Adjust R258 to give a reading of 11.5°.

5.3.4.3.2 30°Peak-to-Peak Jitter Range (Always Perform Second)

Step 1. Set the meter switch in the 30° P-P jitter range.

Step 2. Adjust the sidetone oscillator for a level of

-20.0 ±0.1 dB. This corresponds to a peak-to-peak jitter value of 11.5°.

Step 3. Adjust the 30° calibration control R257 for this meter reading.

5.3.4.4 Level Detector

Step 1. Lower the input level to -40 dBm. An external level meter should be used to obtain accurate readings at this level.

Step 2. Adjust the level calibrate control, R239, to just extinguish the CAUTION light. The CAUTION light should again illuminate when the input level is dropped an additional 2 dB.

5.3.4.5 Out-of-Lock Detector

Step 1. Connect a 0 dBm 1035 Hz signal to the INPUT terminals.

Step 2. Adjust the CAUTION FREQUENCY control R232 to just illuminate the CAUTION light.

Step 3. Slowly lower the input frequency to extinguish the CAUTION light and continue until the CAUTION light again illuminates. This frequency should be between 990 and 975 Hz.

5.2.3.6 Power Supply Voltage

Step 1. Connect an accurate DC voltmeter between terminals H and I of the power supply. Adjust R516 for -15.0 volts.

Step 2. Move the DC voltmeter to terminals H and G and adjust R517 for an output of +15.0 volts DC.

5.4 PARTS IDENTIFICATION

Parts lists for the Model 56 are contained in Tables 5-3, 5-4, and 5-5, and describe all electrical parts used in the unit. Schematic diagrams and P.C. board component location diagrams are shown in Figures 5-3, 5-4, 5-5, 5-6, and 5-7.

TABLE 5-3 MODEL 56 MAINFRAME PARTS LIST

Fig.No.	Ref. No.	Description	Part No.	Mfr.
5-3	C101, 102	Capacitor, ceramic disc, .01 mfd, 10%, 1.6K vdc	DPL	CRL
	D301, 302	Diode, germanium	1N191	GE
	DS101, 102	Pilot lamp, incandescent, 28V, .030 amp.	327	Chicago Lamp
	F101	Fuse, 250 vac 1/2 amp., S.B.	3AG	Littlefuse
	J101	AC receptacle	AC3G	Amphenol
	J102 thru J104	Binding post	29-1	Grayhill
	J105, 106	Phone jack, 3-circuit	12B	Switchcraft
	L101	Holding coil	C1709	Stancor
	M101	Meter, 0-50 microamp.	44-039	HLI
	R101	Resistor: fixed, composition, 900 ohm, 5%, 2w		A.B.
	R102	" " " , 600 ohm, " "		"
	R301	Resistor, cermet variable, 5.0K, 10%	89PR	Helipot
	R302, 303	Resistor, deposited, fixed, 10.0K, 1%	RN60D	
	S101	Switch, push; 1-pole, 2-position	616	Marco Oak
	S102	Switch, rotary; 3-pole, 3-position	MRA-3-3S	Alco
	S103	" " ; 4-pole, 5-position	K947	JBT

TABLE 5-4 HLI 56-200 P.C. BOARD PARTS LIST

Fig.No.	Ref. No.	Description	Part No.	Mfr.
5-5	C201	Capacitor, polyester, .039 mfd, 5%, 100 vdc	MWR	Standard
	C202	Same as C201		
	C203	Capacitor, polyester, .047 mfd, 5%, 100 vdc	MWR	Standard
	C204	" " ,, .022 mfd, 5%, 100 vdc	"	"
	C205	" " , .0033 mfd, 5%, 100 vdc	"	"
	C206	Capacitor, paper, .1 mfd, 10%, 100 vdc	225P	Sprague
	C207	Capacitor, polyester, .068 mfd, 5%, 100 vdc	MWR	Standard
	C208	" " , .0027 mfd, 5%, 100 vdc	"	"
	C209	Capacitor, paper, .22 mfd, 10%, 100 vdc	225P	Sprague
	C210	Same as C213		
	C211	Capacitor, ceramic disc, 3.3 pf, 1000 vdc	10TCC-V33	Sprague
	C212	" " " , 10 pf, 1000 vdc	10TCC-Q10	"
	C213	" , tantalum, 22 mfd, 10%, 15 vdc	150D	"
	C214	Same as C211		
	C215	" C212		
	C216	" C209		
	C217	" C201		
	C218	Capacitor, polyester, .0075 mfd, 5%, 100 vdc	MWR	Standard
	C219	Same as C217		

TABLE 5-4 HLI 56-200 P.C. BOARD PARTS LIST

Fig.No.	Ref. No.	Description	Part No.	Mfr.
5-5	C220	Same as C207		
	C221	Capacitor, polyester, .001 mfd, 5%, 100 vdc	MWR	Standard
	C222, 223	" " , .47 mfd, 10%, 100 vdc	225PX	Sprague
	C224	Same as C209		
	C225, 226	Same as C213		
	C227	" C213		
	C228	" C209		
	C229	Capacitor, dipped mica, 390 pp, 5%, 500V	CM05FD	Elmenco
	C230, 231	" , polystyrene, .1 mfd, 2.5%, 33 vdc	Type 630	Mial
	C232, 233	Same as C212		
	C234, 235	" C211		
	C236	Capacitor, ceramic, .01 mfd, 25V	Y5S	Mial
	C237,238,239	Same as C209		
	D201 thru D205	Diode, silicon	IN3064	Fairchild
	D206, 207	Diode, silicon, zener	IN706A	Motorola
	D208 thru D214	Same as D201		

TABLE 5-4 HLI 56-200 P.C. BOARD PARTS LIST

Fig.No.	Ref. No.	Description	Part No.	Mfr.
5-5	IC201, 202	Integrated circuit, dual amplifier	MC1458G	Motorola
	IC203, 204	" " "	MC1437L	"
	IC205,206,207	Same as IC201		
	Q201	Transistor, silicon, NPN	2N3566	Fairchild
	Q202	" " , PNP	2N5138	"
	Q203 thru Q209	Same as Q201		
	Q210, 211	Same as Q202		
	Q212	" Q201		
	R201	Resistor: fixed, deposited, 9.09K, 1%, 1/4w	RN60D	
	R202	Resistor: " " , 4.02K, 1%	"	
	R203	" " " , 8.06K, 1%	"	
	R204	" " " , 3.48K, 1%	"	
	R205	" " " , 24.3K, 1%	"	
	R206	" " " , 7.23K, 1%	"	
	R207	" " " , 4.32K, 1%	"	
	R208, 209	" " " , 10K, 1%	"	
	R210	" " " , 100K, 1%	"	

TABLE 5-4 HLI 56-200 P.C. BOARD PARTS LIST

Fig.No.	Ref. No.	Description	Part No.	Mfr.
5-5	R211 thru R214	Resistor: fixed, composition, 10K, 5%, 1/4w		A.B.
	R215, 216	Resistor: fixed, composition, 100K, 5%, 1/4w		A.B.
	R217	" " " , 47K, 5%, 1/4w		"
	R218 thru R222	Same as R215		
	R223	Resistor: fixed, composition, 2.2K, 5%, 1/4w		A.B.
	R224	" " " , 22K, 5%, 1/4w		A.B.
	R225 thru R228	Same as R211		
	R229	Resistor: fixed, composition, 220K, 5%, 1/4w		A.B.
	R230	Same as R215		
	R231	Same as R229		
	R232	Resistor, variable, cermet, 20K, 10%	PRM	Helipot
	R233	Same as R215		
	R234	Resistor: fixed, composition, 1K, 5%, 1/4w		A.B.
	R235	Same as R211		
	R236	Same as R217		

TABLE 5-4 HLI 56-200 P.C. BOARD PARTS LIST

Fig.No.	Ref. No.	Description	Part No.	Mfr.
5-5	R237	Resistor: fixed, composition, 2.2 meg, 5%, 1/4w		A.B.
	R238	Same as R234		
	R239	Resistor, variable, cermet, 1.0K, 10%	72PMR	Helipot
	R240	Same as R223		
	R241 thru R243	Resistor: fixed, deposited, 32.4K, 1%	RN60D	
	R244	Resistor: fixed, deposited, 19.1K, 1%	RN60D	
	R245	" " " , 68.1K, 1%	"	
	R246	" " " , 31.6K, 1%	"	
	R247	" " " , 90.9K, 1%	"	
	R248	Same as R224		
	R249	Same as R247		
	R250	Resistor: variable, cermet, 50K, 10%	72PMR	Helipot
	R251	Same as R224		
	R252	Resistor, variable, composition, 10K, 10%	72PMR	Helipot
	R253	Resistor, fixed, deposited, 14K, 1%	RN60D	
	R254	" " " , 133K, 1%	"	
	R255	Same as R211		

TABLE 5-4 HLI 56-200 P.C. BOARD PARTS LIST

Fig.No.	Ref. No.	Description	Part No.	Mfr.
5-5	R256	Resistor, fixed, composition, 4.7K, 5%, 1/4w		A.B.
	R257, 258	Resistor, variable, 20K, 10%	89PR	Helipot
	R259	Resistor, fixed, deposited, 63.4K, 1%	RN60D	
	R260, 261	Same as R210		
	R262	Same as R245		
	R263	Resistor, fixed, deposited, 2.74K, 1%	RN60D	
	R264	" " " , 18.2K, 1%	"	
	R265, 266	Same as R208		
	R267	Resistor, fixed, deposited, 182K, 1%	RN60D	
	R268	" " " , 255K, 1%	"	
	R269	" " " , 51.1K, 1%	"	
	R270	Resistor, fixed, composition, 1 meg, 5%, 1/4w		A.B.
	R271	Same as R211		
	R272	" R246		
	R273	Resistor, fixed, deposited, 86.6K, 1%,	RN60D	
	R274	Resistor, variable, composition, 1K, 10%	89PR	Helipot
	R275	Same as R211		
	R276, 277	" R224		

TABLE 5-4 HLI 56-200 P.C. BOARD PARTS LIST

Fig.No.	Ref. No.	Description	Part No.	Mfr.
	R278	Same as R211		
	R279	" R254		
	R280	Resistor, fixed, composition, 100 ohm, 5%, 1/4w		A.B.
	TR201	Over voltage protector	CG2306	Signalite

TABLE 5-5 POWER SUPPLY PARTS LIST

Fig.No.	Ref. No.	Description	Part No.	Mfr.
5-7	C501, 502	Capacitor, electrolytic, 330 mfd, 35 vdc	TAD	IEC
	C503	Capacitor, paper, .22 mfd, 10%, 100 vdc	225P	Sprague
	C504, 505	" , ceramic, 200 pf, 10%	Z5U	"
	C506, 507	" , electrolytic, 22 mfd, 35 vdc	TAD	IEC
	D501, 502	Full wave bridge silicon rectifier	FW-100	Mallory
	D503, 504	Diode, silicon	1N4002	Fairchild
	D505	Diode, zener	1N751A	GE
	D506 thru D510	Diode, silicon	1N3064	Fairchild
	R501, 502	Resistor, fixed, composition, 2.4 ohm, 5%, 1/2w		A.B.
	R503, 504	" " " , 47 ohm, 5%, 1/4w		"
	R505, 506	" " " , 1K, 5%, 1/4w		"
	R507, 508	" " " , 1.5K, 5%, 1/4w		"
	R509	" " " , 820 ohm, 5%, 1/4w		"
	R510	" " " , 15K, 5%, 1/4w		"
	R511	" " " , 22K, 5%, 1/4w		"
	R512	" " " , 680K, 5%, 1/4w		"
	R513	Same as R510		

TABLE 5-7 POWER SUPPLY PARTS LIST

Fig.No.	Ref. No.	Description	Part No.	Mfr.
5-7	R514	Resistor, fixed, 1K, 1%	RN60D	
	R515	Resistor, fixed, 1.82K, 1%	RN60D	
	R516, 517	Resistor, variable, 1K, 10%	72YWR1K	Helipot
	R518	Resistor, fixed, 4.75K, 1%	RN60D	
	R519	Resistor, Fixed, 5.11K, 1%	RN60D	
	Q501	Transistor, silicon	62203	RCA
	Q502	Transistor, silicon	62204	RCA
	Q503	Transistor, silicon	2N5138	
	Q504, 505	Transistor, silicon	2N3566	
	Q506	Same as Q503		
	Q507	Same as Q504		

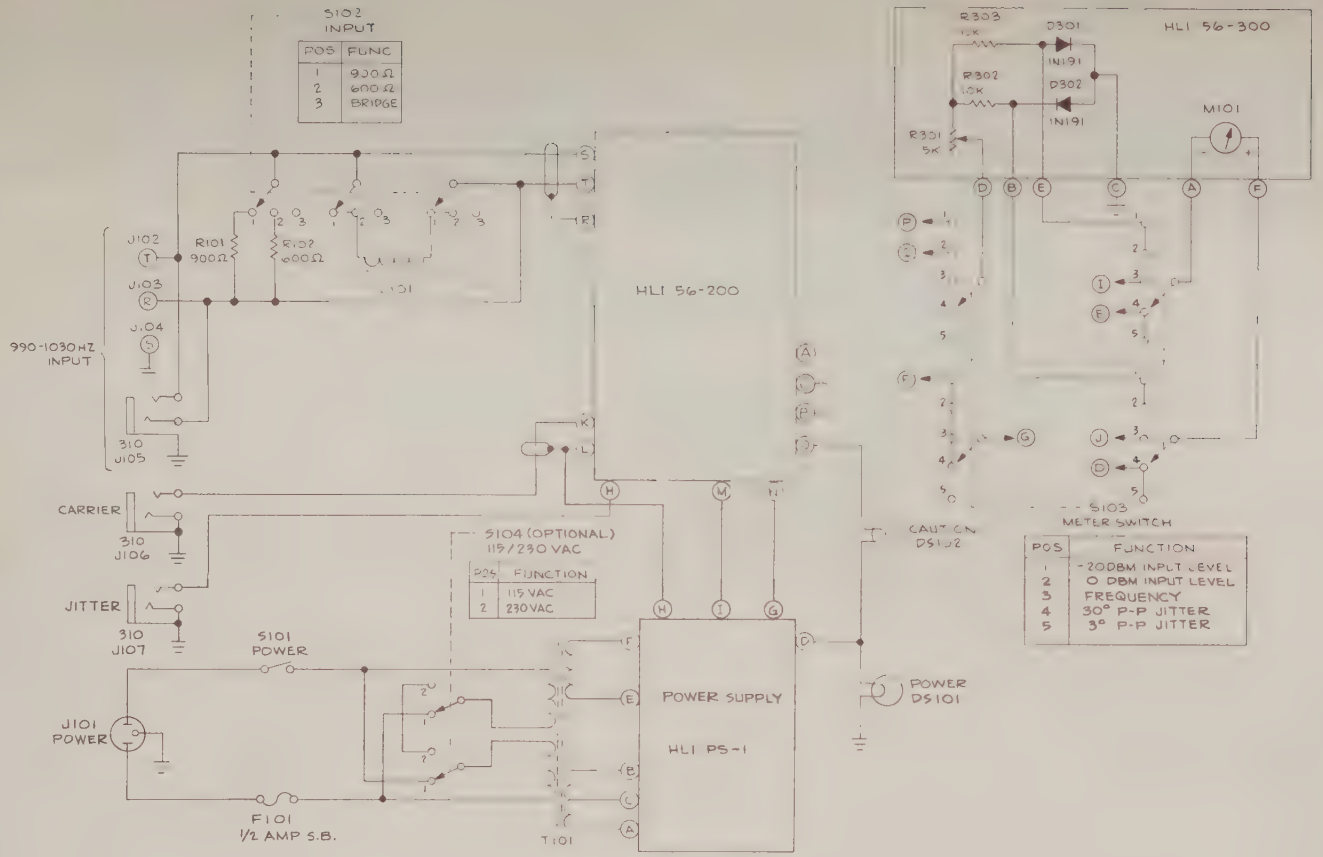


FIGURE 5-3 MODEL 56 MAINFRAME SCHEMATIC DIAGRAM

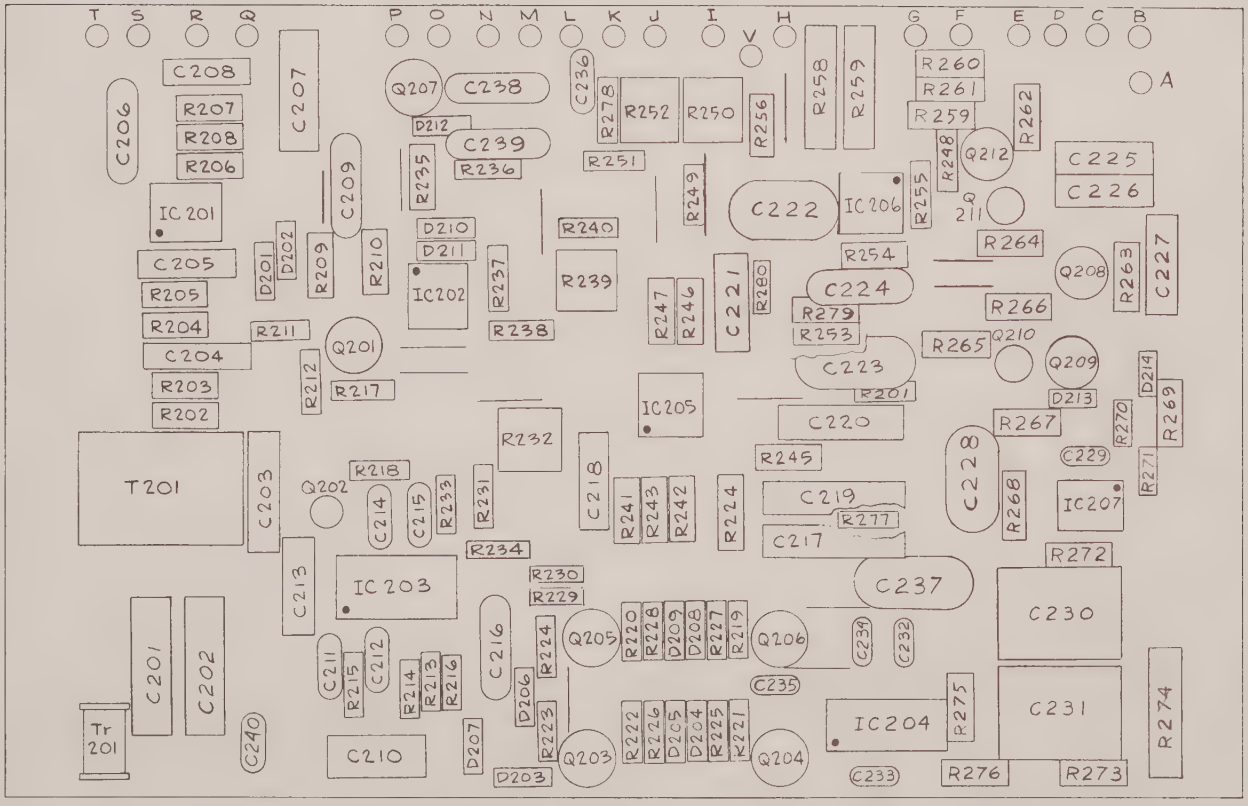
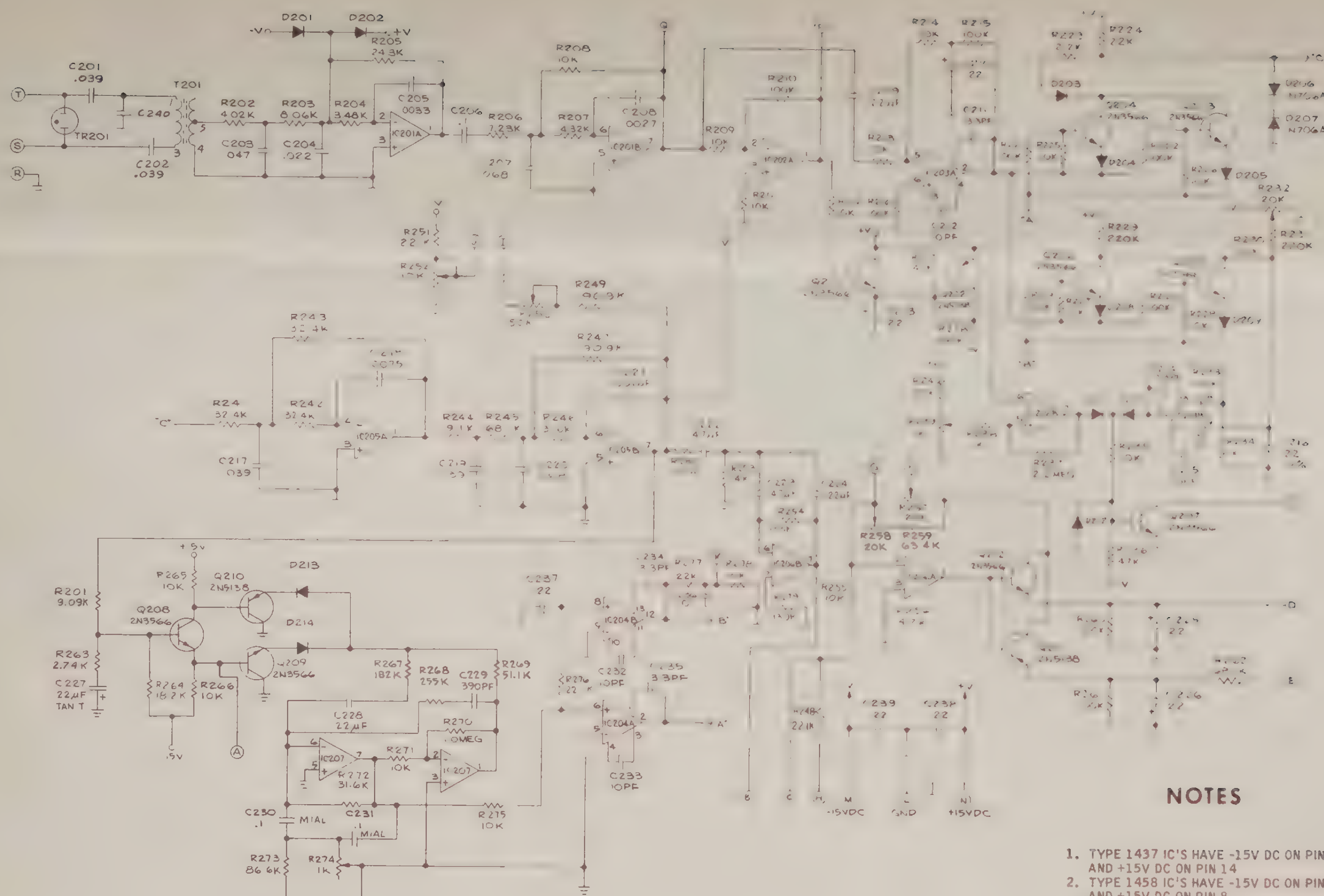


FIGURE 5-4 HLI 56-200 P.C. BOARD COMPONENT LAYOUT


D201
D202
-V
+V
R205
24.3K
C201
.039
T201
C240
R202
4.02K
R203
8.06K
R204
3.48K
C205
.0033
IC201A
TR201
C202
.039
C203
.047
C204
.022
C206
R206
7.23K
R208
10K
R207
4.32K
C208
.0027
IC201B
R209
10K
R210
10.1K
R211
10K
IC202A
R249
R251
22K
R243
R24
32.4K
C217
.039
IC205A
R244
9.1K
R245
68K
R258
20K
R259
63.4K
C234
3.3PF
C235
3.3PF
C237
22
IC204B
IC204A
C232
10PF
C233
10PF
R276
C239
22
C238
22
-15VDC
GND
+15VDC
R265
10K
Q210
2N5138
D213
R201
9.09K
Q208
2N3566
D214
Q209
2N3566
R263
2.74K
C227
22µF
TAN T
R264
18.2K
R266
10K
R267
182K
R268
255K
C229
390PF
R269
51.1K
C228
22µF
R270
10MEG
IC207
R271
10K
R272
31.6K
C230
.1
C231
.1
MIAL
R275
10K
R273
86.6K
R274
1K
R232
20K
R223
220K
R224
22K
R215
100K
D203
D204
D205
D206
N706A
D207
N706A
2N5138

NOTES

1. TYPE 1437 IC'S HAVE -15V DC ON PIN 7 AND +15V DC ON PIN 14
2. TYPE 1458 IC'S HAVE -15V DC ON PIN 4 AND +15V DC ON PIN 8
3. ALL UNMARKED CAPACITY VALUES IN MFD
4. ALL UNMARKED DIODES ARE TYPE IN3064
* SELECTED VALUE

FIGURE 5-5 HLI 56-200 P.C. BOARD SCHEMATIC DIAGRAM

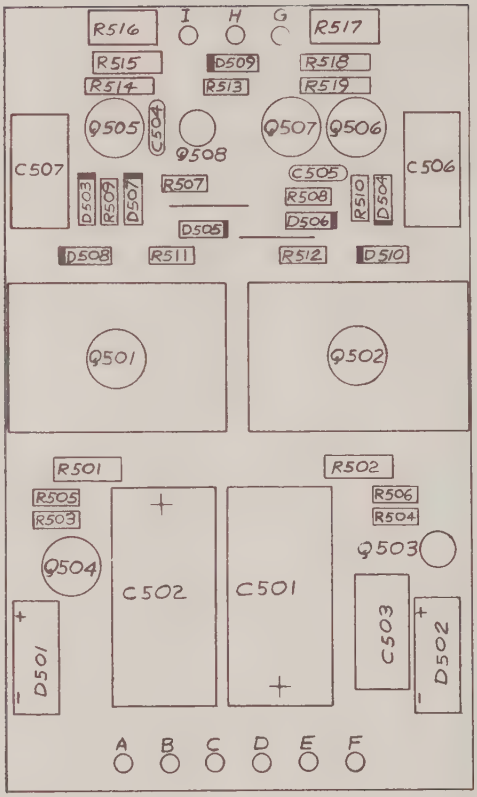


FIGURE 5-6 POWER SUPPLY COMPONENT LAYOUT

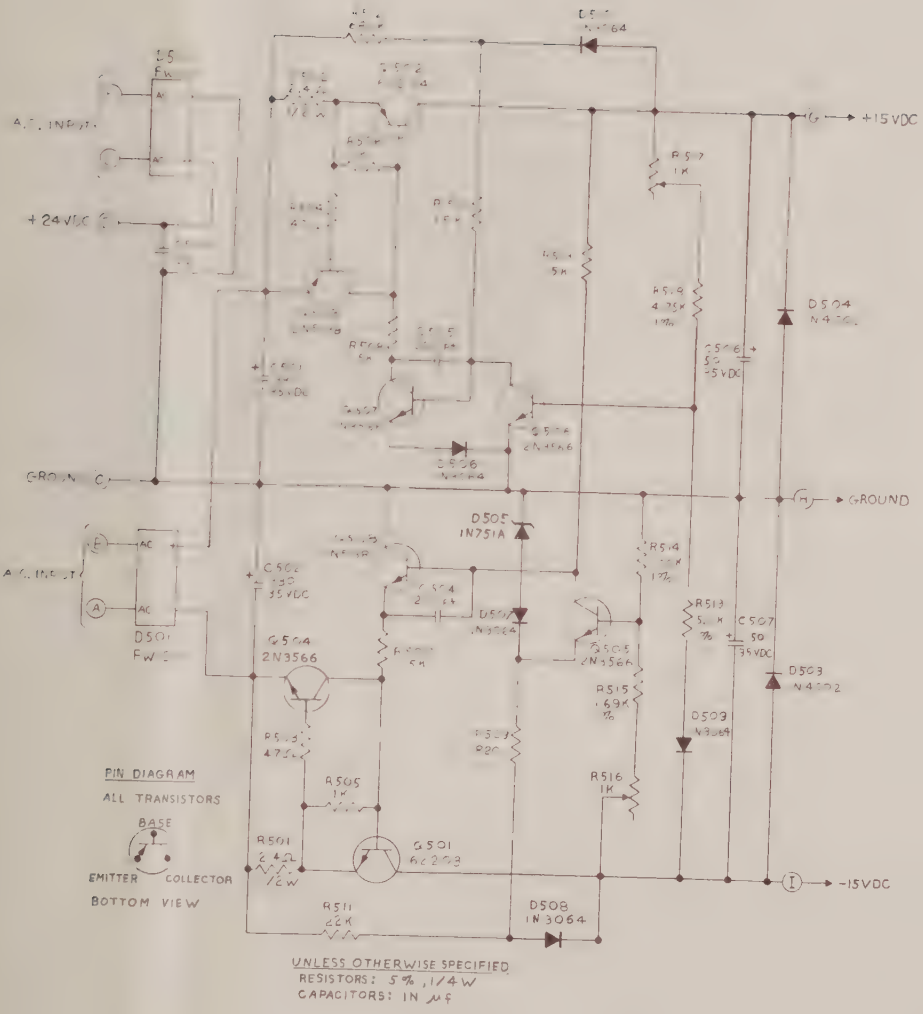


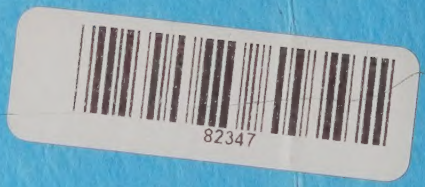
FIGURE 5-7 POWER SUPPLY SCHEMATIC DIAGRAM

WARRANTY

All Hekimian Laboratories, Inc., products are warranteed against defects in materials and workmanship for a period of one year from date of delivery. HLI will repair or replace at no cost, products which prove to be defective during the warranty period. Upon authorization by HLI, the equipment may be returned to the factory prepaid for repair. Upon completion of repair, the equipment will be returned at HLI expense. If, upon examination of the defective item, it is evident that failure was not due to defective workmanship or material, HLI will bill the purchaser for the cost of replacement or repair, including transportation charges. HLI does not warrant the merchantability of its products and does not make any warranty, expressed or implied, other than the warranty contained herein.

Hekimian Laboratories, Inc.

Rockville, Maryland 20850


82347